## Art. VI.—*Proportional Representation.*

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[Read July 8th, 1880.]

Various plans have been proposed for obtaining a nearer approach to proportional representation than is afforded by the majority system in common use. These plans have been classed by M. Ernest Naville under two heads, "Empirical Systems," and "Scientific Systems." Under the first head are included the single vote, the cumulative vote, and the restricted vote. These systems are in many respects superior to the majority system, but they are one and all open to a very serious objection. It is that the electors are compelled to submit to the dictation of party leaders, and adopt some process of organisation under pain of compromising their party, and depriving it of its fair share of representation. Besides this, if it should happen that the calculations of the leaders are wrong, the party does not obtain its fair share of the representation. Thus, in a three-cornered constituency, two-fifths of the electors may easily return two of the representatives, leaving the majority of three-fifths with one representative only.

Again, the single vote and the cumulative vote are liable to an enormous waste of voting power. Thus, for instance, at the School Board elections in 1870, for Marylebone, Lambeth, Sheffield, and Birmingham, the percentages of wasted votes were 66, 57, 54, and 48 respectively.

Under the head of "Scientific Systems," M. Naville includes the preferential vote, the independent ticket vote, and the uninominal vote.

The first of these, due to M. Andrae and Mr. Hare, is fully explained in the subsequent part of this paper. The second and third are modifications of the preferential vote. In the second, any body of electors exceeding a given number (say 30) can put forward a "ticket." The electors are then permitted to vote for any of these tickets. In the third, instead of each elector making a list of candidates to whom his vote may be successively transferred, each candidate makes a list of the other candidates to whom the

superfluous or useless votes given to him are to be transferred. These lists are published before the election, and each elector votes for one candidate.

The preferential vote is the only plan which will make the electors entirely independent of party leaders and party organisation, and it appears to be the most perfect system which can be devised for approximating to proportional representation. It is to be particularly noticed that the preferential vote applies to all cases alike, whether there be one, two, three, or a hundred vacancies to be filled. Hence it might be applied to the present electorates of this colony. But a great advantage would be gained by doing away with electorates returning one member. For with equal electorates returning one member apiece, it is possible under any system of voting for a trifle over 25 per cent. of the electors who vote to return a majority of the representatives; and if the electorates be not equal, a still smaller percentage might return the majority. Now, although exactly the same result could happen under the majority system if the electorates have more than one member apiece, the case is very different with the preferential vote. Under that system, with equal electorates returning each $n$ members, it would not be possible for less than $\frac{1}{2}\frac{n}{n+1}$ of the whole number of voters to return half of the representatives. Thus, if each electorate had five representatives, it would require at least 42 per cent. of the voters to return half the representatives; whereas, under the majority system, 25 per cent. could return half the representatives.

With single electorates we see, then, that the majority system and the preferential system are alike subject to the anomaly just pointed out. But the preferential vote would be superior in two respects. First, we should be sure that the majority would rule in each electorate, whereas, under the so-called majority system, we have no such certainty; and, secondly, the electors themselves would be able to decide who was the best candidate on their own side, whereas at present the candidates have to be chosen and nominated by party leaders. If, however, the preferential vote be applied to electorates returning two or more representatives, the anomaly just described is got rid of to a very great extent, and if the number of representatives be made sufficiently great, it disappears completely.

In illustration of the preceding remarks on the majority system, it may be mentioned that, at the last general election

in this colony, the successful party had a majority of 9 in the 27 single electorates where contests took place, whilst the voting powers of the two parties in those electorates were approximately in the proportion of 19 to 17. The representatives returned by the larger electorates were very evenly divided between the two parties; but, in the absence of an analysis of the voting in each electorate similar to that supplied by the scrutineers at Sandhurst and at West Melbourne, it is quite impossible to estimate accurately the relative voting powers of the two parties. So far as any conclusion can be drawn from the published returns, it would appear that the voting powers of the two parties were very evenly balanced. Hence we may infer that the state of representation obtained in the large electorates was much more perfect, taken on the average, than that obtained in the single electorates. There is, however, no reason why this should be so. In fact, the single electorates might have been expected to give the better average result; for if a given number of representatives have to be elected, the smaller the number of electorates, and the larger the number of representatives returned by each, the greater would the anomalies of representation probably be. In particular, if there were only one electorate, it is highly probable that all the representatives might be returned by one party.

We may conclude, then, that if the preferential vote were applied to the present electorates of this colony the representation would be much more perfect than it can be under the present plan; that it would be still more perfect if the electorates were enlarged, and their number decreased, and that if each electorate returned at least five representatives we should have a very fair approximation to proportional representation. By limiting the number of representatives returned by each electorate to five, six, or seven, we should not have any difficulty in filling any vacancies which might arise from time to time; whereas, if the whole colony were thrown into one electorate, some totally new principle would have to be adopted for dealing with such cases.

The methods hitherto given by Mr. Hare and others for dealing with the contingent votes are open to certain objections. These may be briefly stated as follows:

(1.) The result of the election depends to a certain extent upon chance.

(2.) In the course of the election a number of votes are generally wasted unnecessarily.

(3.) At the end of the election candidates are returned on fewer votes than those required for the return of candidates who are elected at an earlier stage of the election.

The object of this paper is to examine some of these points, and to give a process, from which the element of chance is completely eliminated, by which no votes are wasted unnecessarily, and by which all the representatives are returned on as equal terms as possible.

In the system of representation proposed more than twenty years ago by Mr. Hare each elector has one vote only. But, in order to guard against waste of voting power, each elector is permitted to indicate other candidates in successive order for whom he would be willing to vote in case his vote is not required for the candidate of his first choice. Thus, each elector is furnished with a ballot-paper containing the names of the candidates in alphabetical order, and the elector places the figure 1 opposite the candidate of his first choice, *i.e.*, the candidate for whom he wishes to vote. He is also permitted to place the figures 2, 3, 4, &c., opposite the names of other candidates, for whom in their successive order he would be willing to vote in case his vote is not required for the candidate of his first, second, third, &c., choice. It is better to use this form of ballot-paper than to require the electors to write down in successive order the names of the candidates they are willing to vote for. Further, it is not wise to place any limit upon the number of names which may be indicated; any such restriction would be a direct inducement to party organisation. When the voting is over, the first thing to be done is to ascertain the number of votes cast for each candidate, counting only the names marked with the figure 1, and thence the total number of votes cast. The papers polled for the several candidates are placed in separate heaps and the heaps arranged in order, placing first those containing

Form of Ballot Paper.

| Order of Preference. | Names of Candidates. |
|---|---|
| 4 | A |
| 2 | B |
| | C |
| 3 | D |
| 1 | E |
| | F |

most papers. In case of equality the Returning Officer must exercise a casting vote. A list of the candidates in the order in which their heaps are arranged is then made out. The order of the candidates on this list will be frequently referred to as the order of priority of the candidates on the first count, and use will be made of it in all cases where otherwise it would be necessary for the Returning Officer to exercise a casting vote.

The next step is to determine the *quota*, or number of votes sufficient for the return of a candidate. This is done by the following rule.

Divide, to the exclusion of fractions, the number of votes polled by a number greater by one than the number of seats to be filled, and add one to the result.

Thus, if there be 15 seats the quota would be 100 if the number of votes polled were 1584 or 1599, or any number intermediate to these two.

Having determined the quota, the next step is to ascertain what candidates, if any, have attained the quota. Here, then, two cases arise. First, let us suppose that no candidate has more than the quota. Then the next step is to exclude the candidate who is lowest on the first count. The heap of the excluded candidate is then examined, and the papers in it are transferred to the heaps of the candidates, if any, who are indicated as the second choice of the electors. For example, let A, B, C, &c., denote the candidates, of whom Z is the lowest, and suppose, on examination, we find that ZA = 12, ZB = 10, Z1 = 23, where ZA is used to denote the number of papers on which Z is marked 1 and A is marked 2, and so on, whilst Z1 denotes the number of papers on which no name is marked except that of Z, we should then transfer the 12 ZA papers to A's heap, and the 10 ZB papers to B's heap. The 23 Z1 papers are of no use, and are lost.

We should now proceed to a new scrutiny. If, however, any papers are lost, as in the preceding example, the total number of papers which can have any effect on the election is diminished, and we should determine a new quota, taking account only of the useful papers left. For example, if the number of votes cast be 1599, as supposed above, we have now in the example just given 1576 useful papers left, and the new quota would be 99.

This process of excluding the lowest on each count, and distributing any papers which can be distributed, and

diminishing the quota every time a sufficient number of papers are lost, would have to be repeated until either there remain no more candidates than vacancies, or until some one obtains more than the quota.

If there is only one vacancy to be filled, the whole process of the election falls under this case. The quota for any count is an absolute majority of the useful votes left.

It is also to be noticed that if at any stage a candidate has a number of votes greater than the sum of the votes of all the candidates who have less than he has, then all such candidates may be at once excluded; in particular, if any candidate has an absolute majority on the first count he is elected.

Next, let us suppose that at least one candidate has more than the quota. Let A, B, C, &c., denote the candidates who have a quota or more, and let P, Q, R, S, &c., denote the candidates who have less than the quota. The first thing to be done is to examine the heaps of A, B, C, &c., so as to arrive at the information shown in the following table:

TABLE I.

| | P | Q | R | S |
|---|---|---|---|---|
| A | A1 | AP | AQ | AR | AS |
| B | B1 | BP | BQ | BR | BS |
| C | C1 | CP | CQ | CR | CS |

Here A1 denotes the number of papers on which A is marked 1 and on which no other names, if any, are marked, save those of the elected candidates, B, C, &c., and so for B1, &c. AP denotes the number of papers on which A is marked 1, and on which P is marked as the prior choice of the elector amongst the unelected candidates, P, Q, R, S, &c.; and so for AQ, and BP, &c. The heaps of A, B, C, &c., are broken up into corresponding parcels.

For convenience, the numbers A, B, &c., are written at the ends of the rows, and P, Q, R, &c., at the heads of the columns, each set being written down in the order of priority of the candidates on the first count. The number by which the number of votes of an elected candidate

exceeds the quota is called the surplus of that candidate. Thus, the candidates A, B, &c., having a surplus, we see that, (1) that surplus can be transferred to the unelected candidates, P, Q, R, &c.; (2) there are many ways in which this can be done; (3) the result of the election may depend very materially upon the way in which it is done.

M. Andrae proposed to make this distribution by lot. Mr. Hare proposes to make it by a series of rules, depending on, (1) the different electoral divisions, &c., in which the votes were polled; (2) the number of names indicated on the voting-papers; (3) a prescribed order among the different polling-booths at which the votes were polled; (4) the order in which the papers were polled. The first of these principles was adopted in order to preserve local representation as much as possible. The second principle seems to be very objectionable, on the ground that it makes it necessary for a voter to mark a large number of names on his voting-paper in order to give the paper a reasonable chance of being transferred, and hence a great inducement is held out to voters to mark a large number of names indiscriminately. The third and fourth principles introduce the element of chance, so that, in fact, the result of an election may depend upon the order in which the voters go to the poll, or upon the arbitrary decision of the authority that prescribes the order of the polling-booths. It can scarcely be doubted that a method of distribution which depends only upon the voting papers themselves, and not upon any external circumstances, such as the order of polling, place of polling, &c., would be more satisfactory. Several such methods might be suggested; but any method to be satisfactory must satisfy the following conditions:

I. It must be reasonably simple.

II. It must not put a premium upon organisation, such as voting on a uniform ticket.

III. It must be as equitable as the circumstances of the case admit.

So far as I know no such method has been published; and it is one of the principal objects of this paper to describe a method which, I hope, will be found satisfactory.

In the method proposed the first principle is to divide the surplus of an elected candidate as equally as possible amongst the unelected candidates, who are indicated as the next choice of the electors on the papers of the elected candidate. An immediate consequence of this principle is

that as small an alteration as possible is made in the order in which the unelected candidates stand. When the surplus of a candidate is distributed all the unelected candidates next indicated on his papers are helped forward, and each, as far as possible, to the same extent. Thus, indirectly, greater weight is given to the first choice of each elector.

In order to show the mode of carrying out this principle, the following table is constructed.

TABLE II.

| | P | Q | R | S | |
|---|---|---|---|---|---|
| | P | Q | R | S | |
| A | ap | aq | ar | as | a |
| B | bp | bq | br | bs | b |
| C | cp | cq | cr | cs | c |

The names at the ends of the rows and columns are the same as in Table I. *a* denotes A's surplus, *ap* denotes the number of papers which are to be transferred from A to P, and so on. The letters P, Q, &c., in the first row of the table, denote the numbers of papers in the heaps of P, Q, &c. The sum of the numbers *ap, aq, ar,* &c., is equal to *a*, or to the sum of the numbers A P, A Q, A R, &c., whichever is the smallest. No one of the numbers *ap, aq,* &c., can be greater than the corresponding number in Table I.; those which are less are all equal to one another, or differ by unity at the most. The method of finding these numbers is as follows. Suppose papers taken one by one from the parcels A P, A Q, &c., in this order, and let the process be continued and repeated until either the number of papers so taken is equal to A's surplus, or all the heaps, A P, A Q, &c., are exhausted. Then *ap* denotes the number of papers taken from the parcel A P, and so on.

This merely shows how the numbers *ap, aq,* &c., are arrived at; it does not show us what papers are to be taken from the parcel A P and transferred from A to P. Before considering the rule by which we are to select the *ap* papers from the parcel A P, it is as well to notice one or two

points in connection with the method just described. It will be noticed that papers are transferred to all candidates to whom it is possible to transfer any. The magnitude of the numbers A P, A Q, &c., has not much influence on the magnitude of the numbers *ap*, *aq*, &c. Thus, for instance, if there be a large vote on a party ticket on which the first name marked is A, and the second P, this ticket is not permitted to overpower the electors who have also voted for A, but have not followed the ticket. Nor, on the other hand, can it be said that any injustice is done to the electors who voted on the ticket, for at least as many papers are transferred from A to P as from A to any other candidate. Thus it will be seen that the method is such that no inducement is held out to the electors to vote on a ticket.

It is now to be noticed that, if the papers transferred from A to P have not subsequently to be transferred from P to some other candidate, it is quite immaterial what particular *ap* papers we transfer from the parcel A P to P. If, however, by means of this transference and other transferences from B, C, &c., to P, P's votes be raised above the quota, P will have a surplus to distribute. But, as already pointed out, the names indicated after P on the papers in P's heap have not very much influence on the numbers to be passed on from P to the remaining unelected candidates. Hence we see that we can, without influencing to any great extent the subsequent course of the election, adopt a simple but somewhat empirical rule for selecting the papers from the A P parcel to be passed on to P. The rule proposed is as follows:

Break up the parcel A P into smaller parcels, according to the names next indicated, *ignoring* the names of elected candidates. Let the parcels be denoted and arranged as follows:

A P Q, A P R, A P S, . . . A P1.

Here A P Q denotes the parcel in which are placed all the papers on which Q is the unelected candidate indicated next after P, and so on for the rest; whilst A P1 denotes the parcel in which are placed the papers on which *no* unelected candidates are indicated after P.

We now transfer to P as many of the above parcels as we can without surpassing the number *ap* of papers which are to be transferred, taking the parcels in the order above indicated. It may happen, of course, that we thus get a

number of parcels making up exactly the number *ap* of papers to be transferred; but this will not always occur. Let us suppose that, after taking as many parcels as possible, as directed above, the parcel next in order is the parcel A P S: we have then to select the balance of the surplus, *aps* suppose, from the parcel A P S.

We now repeat the process just gone through, *i.e.*, we break up the parcel A P S into the smaller parcels A P S Q, A P S R, &c., A P S1, where, from what has gone before, the notation will be obvious. Just as before, take as many complete parcels as we can in the order indicated without surpassing the number, *aps*, to be transferred. We can continue this process until we either get the number of papers we want to transfer made up exactly by a number of whole parcels, or until we exhaust the names of the unelected candidates. In the latter event, the papers in the parcel we have to select from are all exactly alike, if no attention be paid to the names of elected candidates which may be indicated on such papers.

In all previous methods all such names are completely ignored from this stage, so that the papers are, for all purposes of this election, exactly alike. Hence we can pick out exactly the number we want without exercising any discretion.

But in the method now proposed, as explained later on, use may be made of the names of such elected candidates.

Hence, then, it is necessary to prescribe a further process of selection. This process is exactly the same as that just described, substituting names of elected candidates for names of not-elected candidates. Thus, ignoring the names of not-elected candidates, the parcel we have to select from is broken up as follows:

A B, A C, A D, . . . A1,

and the rest of the process, being exactly similar to that already given, need not be further described.

This process can be continued, if necessary, until we have exhausted the names of the elected candidates. We shall then find that the papers in the parcel we have to select from are all exactly alike, except as regards the order in which the names of the elected candidates are arranged amongst the names of the not-elected candidates.

Thus, writing down only the names of the indicated

candidates in the order in which they are indicated, the parcel we have to select from might contain papers such as

A P S B R C T D
A B P S C R T D
A B P S C R D T

Accordingly, one more process of differentiating the papers must be described. The parcel we have to select from is broken up into two, the first parcel consisting of papers in which the second indicated name is that of a not-elected candidate; the second consisting of papers in which the second indicated name is that of an elected candidate.

As before, we now transfer the whole of the first parcel, if we can do so without surpassing the number to be transferred, and break up the second parcel according to third indicated names on the plan just described; or we may have to break up the first parcel in that way. This process can be continued, if necessary, until it exhausts itself; and in that event the papers in the parcel we have to select from will be all exactly alike, so that we can take exactly as many papers as we want without the exercise of any discretion.

This, then, brings us to the end of a uniform and systematic process for distributing surplus. We see, then, that unless one or more of the numbers A1, B1, &c., be greater than the quota, every surplus can be completely distributed by this process. Let us assume, then, for the present, that such cases will not occur. Then, after distributing the surplus of every elected candidate by the process just described, we must ascertain the number of papers in the heaps of the unelected candidates, P, Q, &c. These numbers are at once ascertained by adding up the numbers in the different columns of Table II. If any candidates are now raised above the quota, we must apply again the same process of distributing surplus, and repeat the process until a distribution has been made which does not give rise to a fresh election. After this, the candidate who is now lowest on the poll must be excluded; all papers in his heap, which can be so transferred, must be transferred to not-elected candidates; those which cannot be so transferred, but which can be transferred to elected candidates, must be so transferred; and the remainder, if any, being lost, must be withdrawn from the election and a new quota determined. If by this process any candidate be raised above the quota, the process of

distribution must be applied; but if no one be raised above the quota, the process of exclusion must be again applied.

Thus we must proceed by successive applications of the processes of distribution of surplus and transference of papers of excluded candidates until all the vacancies are filled, or there remain no more candidates than vacancies.

It is of importance to notice that the process of selecting the *ap* papers from the parcel A P may be postponed under certain circumstances. For if, after constructing Table II., we see that the distribution will not cause any fresh election, we may at once pass on to the process of exclusion.

In illustration of the above process, suppose that there are 11 candidates for 7 vacancies and that the whole number of votes polled is 799, so that the quota is 100. The result of examining the parcels of papers is shown in the table marked (*a*).

(*a*)

| | P | Q | R | S | T | U | V | Total. |
|---|---|---|---|---|---|---|---|---|
| | 13 | 10 | 7 | 6 | 5 | 3 | 2 | 46 |
| A | 47 | 101 | 10 | 15 | 111 | 8 | 7 | 3 | 302 |
| B | 3 | 14 | 20 | 31 | 30 | 17 | 25 | 19 | 159 |
| C | 17 | 32 | 21 | 49 | 11 | 7 | 5 | 4 | 146 |
| D | 31 | 2 | 43 | 57 | 7 | 2 | 3 | 1 | 146 |
| | 98 | 162 | 104 | 159 | 165 | 39 | 43 | 29 | 799 |

This table is the table described above as Table I., with the addition of two rows and one column. The first of these rows shows the number of papers in the heaps of the unelected candidates, P, Q, R, S, T, U, V, and the last shows the sum of the numbers above it in each column. The new column, marked "Total," shows the sum of the numbers in each row. The last row and the last column when added up give each 799, which affords a verification. Constructing now Table II. as described above, with the addition

of a fresh row containing totals, we get the table marked (β),

| (β) | P | Q | R | S | T | U | V | Total. |
|---|---|---|---|---|---|---|---|---|
| | 13 | 10 | 7 | 6 | 5 | 3 | 2 | 46 |
| A | 80 | 10 | 15 | 79 | 8 | 7 | 3 | 202 |
| B | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 59 |
| C | 8 | 8 | 7 | 7 | 7 | 5 | 4 | 46 |
| D | 2 | 16 | 15 | 7 | 2 | 3 | 1 | 46 |
| | 112 | 53 | 53 | 107 | 30 | 26 | 18 | 399 |

and see that P has a surplus of 12, and S a surplus of 7. We then transfer papers from the heaps of A, B, C, D to those of P, Q, &c., by the rules explained above.

The next two tables, (γ), (δ), show the process of dis-

| (γ) | | Q | R | T | U | V | Total. |
|---|---|---|---|---|---|---|---|
| | | 53 | 53 | 30 | 26 | 18 | 180 |
| P | 2 | 8 | 50 | 28 | 13 | 11 | 112 |
| S | 3 | 50 | 40 | 11 | 2 | 1 | 107 |
| | 5 | 111 | 143 | 69 | 41 | 30 | 399 |

| (δ) | Q | R | T | U | V | Total. |
|---|---|---|---|---|---|---|
| | 53 | 53 | 30 | 26 | 18 | 180 |
| P | 3 | 3 | 2 | 2 | 2 | 12 |
| S | 2 | 2 | 1 | 1 | 1 | 7 |
| | 58 | 58 | 33 | 29 | 21 | 199 |

tributing the surplus of P and S. All surplus is now distributed, and the election is completed in two more steps, shown in Table (ϵ). V, being the lowest, is excluded. His

(ϵ)

| Q | R | T | U | V |
|---|---|---|---|---|
| 58 | 58 | 33 | 29 | 21 |
| 8 | 13 | 0 | 0 | — |
| 66 | 71 | 33 | 29 | — |
| 24 | 38 | — | — | — |
| 90 | 109 | — | — | — |

21 papers are transferred to Q, R, as shown in the second row of Table (ϵ). We now notice that the two lowest, T, U, having only 62 votes between them, whilst the next lowest has 66, may both be excluded. This being done, the fifth row shows R to have 109, which is more than the quota, so that the election now terminates with the election of R.

We have now to consider what is to be done if any of the numbers A1, B1, &c., be greater than the quota. If any such cases occur, they afford a simplification of the process previously described. For if A1, B1, be each greater than the quota, the whole of the parcels A P, A Q, &c., B P, &c., can be at once transferred to P, Q, &c., and no selection is necessary. Let us now consider how such cases can arise. It is plain that electors may decline to indicate more than one name, or, as it is commonly expressed, they may "plump." If, then, A has more than a quota of plumpers, the case in question will occur. But it may also occur in other and much more likely ways.

Suppose, for instance, that more than two quotas of electors vote only for A and B, then if at least one quota vote for A, and at least one quota vote for B, the case in question will occur; and similarly for a larger number of candidates. It is obvious that in all such cases votes would be lost; and in order to obtain proportional representation as nearly as possible, these lost votes should be withdrawn from the election, and a new and smaller quota obtained for filling the remaining vacancies, if any.

But, further, in the instance just given, suppose that some of the electors voted for C, as well as for A and B, then it is plain that the votes are not necessarily lost; if C1 be less than the quota, such votes may be transferred to C, and thus C will again have a surplus, some or all of which can be transferred to not-elected candidates. Thus, suppose we have, writing down only the names of the candidates voted for, 120 papers A B, 100 papers B C, 100 papers C P, the quota being 100, and P not elected, then the case in question occurs; but A's surplus of 20 is not lost, for although we cannot transfer any papers from A to not-elected candidates, yet we can transfer 20 from A to B, then 20 from B to C, and then 20 from C to P.

I proceed then to describe a systematic process for detecting and allowing for all such cases so as to obtain as near an approach to proportional representation as the nature of the votes polled will allow of.

It is obvious, by considering extreme cases, that in a given election we may fall far short of proportional representation; but if such an event occurs, it is due entirely to the fact that the electors have not given a sufficient number of contingent votes. This, no doubt, may occur the first time the method is tried on a large scale, but the electors themselves will soon see and apply the remedy.

After distributing surplus as far as possible by the rule already given, let us suppose that we have A1, B1, C1, &c., greater than the quota, but I1, J1, K1, &c., less than the quota.

We must now seek to distribute the surplus of A, B, C, &c., amongst I, J, K, &c. This can be done by the process already described, substituting the elected candidates, I, J, K, &c., for the unelected candidates, P, Q, R, &c., in the former process. After completing this process, we distribute the newly created surplus of I, J, K, &c., by the former process amongst the unelected candidates, P, Q, &c.

If this process fails to completely distribute the surplus of A, B, C, &c., one or other of two events must occur, viz.:

(1.) We may find A1, B1, C1, &c., still each greater than the quota. Under these circumstances the votes now credited to each of the candidates A, B, C, &c., in excess of the quota are absolutely useless and lost; so that A, B, C, &c., may be withdrawn from the election with their quotas and lost papers, and a new quota be determined and a fresh start be made.

(2.) The candidates A, B, &c., may divide themselves into two groups, A, B, &c.; D, E, &c., so that A1, B1, &c., are each greater than the quota, and D1, E1, &c., are each less than the quota. Under these circumstances, we transfer from A, B, &c., to D, E, &c., as before described, with the same alternative consequences. It is clear, then, that by a repetition of this process we can go on until we either completely distribute all surplus or withdraw a certain number of candidates with a certain number of lost votes, and so obtain a new quota, and commence *de novo*.

So far these processes of distribution have been briefly described. In order to prevent the Returning Officer exercising any discretion, the exact order in which they are to be made must be described. It will be seen that three different cases have been described in which papers can be transferred from the heap of one candidate to the heap of another candidate. These are as follows:

(1.) When a candidate is excluded. This process will now be called "transference."

(2.) When a candidate has a surplus, and, in order to distribute his surplus, it is necessary to use the process of selection. This process will be called "distribution by selection."

(3.) When a candidate has a surplus, and, in order to distribute, it is not necessary to use the process of selection. This process will be called "distribution."

It has already been stated that when we have A1, B1, &c., greater than the quota a simplification occurs, inasmuch as we can distribute to a certain extent without selection. It is now to be further noticed that if we make these distributions and proceed to a new count before making a distribution by selection, we may postpone this last process from time to time, and that it may not be necessary to resort to it at all; and that if we have to resort to this process, it will, in many cases, be much more easy to perform then than if it had been entered upon at the earlier stage. Hence, then, in the plan of operations proposed, as many distributions as possible are made before resorting to the process of distribution by selection. The systematic process which can be applied to all cases is as follows:

The papers are first to be arranged in separate heaps, as already described, and a list of the candidates made out in the order in which they stand on the first count. A series of scrutinies is then to be made, and continued till all the

vacancies are filled, or there remain no more candidates than vacancies. Any scrutiny except the last will involve either a transference, or distribution, or distribution by selection from at least one heap to other heaps, or a withdrawal of at least one heap of exhausted papers.

At the end of each scrutiny the papers will be left arranged in heaps for the next scrutiny. Each scrutiny will be made according to the following rules:

At the commencement of each scrutiny the quota for that scrutiny is to be determined by the following rule:

From the number of votes polled subtract a number equal to the sum of the number of exhausted and lost votes, and divide, to the exclusion of fractions, the difference by a number equal to the number of vacancies to be filled, increased by one and decreased by the number of candidates withdrawn from the election on exhausted heaps of papers. The quotient so obtained, increased by one, shall be the quota.

After determining the quota two cases arise, first, the case where there is a surplus; second, the case where there is no surplus. In the first case, an exhaustive division of the candidates, combined with a series of distributions, is to be made, as follows:

First divide the candidates into two sets, Class O and Not-Class O; Class O consisting of those who have less than the quota (hitherto called not-elected). Next divide Not-Class O into two sets, Class I and Not-Class I; Class I consisting of those whose parcels of papers which are not transferable to Class O are respectively less than the quota; then make distributions from Not-Class I to Class O. Next divide Not-Class I into two sets, Class II and Not-Class II; Class II consisting of those whose parcels of papers which are not transferable to Class I are respectively less than the quota; then make distributions from Not-Class II to Class I. This process is to be continued as far as possible, the general rule being that after distribution from the set Not-Class $r$ to Class $(r-1)$, the set Not-Class $r$ is divided into two sets, Class $(r+1)$ and Not-Class $(r+1)$; Class $(r+1)$ consisting of those whose parcels of papers which are not transferable to Class $r$ are respectively less than the quota; then distributions are made from Not-Class $(r+1)$ to Class $r$.

After the last division and distribution, if the candidates all fall into the set Not-Class $n$, they are to be withdrawn from the election, and their heaps set on one side as

exhausted, and a new scrutiny proceeded with. But if the candidates fall into the set Class *n*, then, (1) if any distribution has been made, a new scrutiny is to be proceeded with; (2) if no distribution has been made, a distribution by selection is to be made from the highest class in which there is any surplus to the next lowest class, and a new scrutiny proceeded with.

In the second case, where there is no surplus, the candidate who now stands lowest is to be excluded, and his papers are to be dealt with as follows:—

All which can be transferred to any candidates who have not been withdrawn or excluded are to be transferred to candidates in the lowest class to which they can be transferred.

Those which can be transferred only to excluded candidates, or cannot be transferred at all, are to be set on one side as lost.

The remaining papers, if any, are to be set on one side as exhausted.

In case of equality, that candidate who is lowest in the order of priority on the first count shall be excluded.

If in this case it should happen that any candidate has a number of votes exceeding the sum of the votes of all who stand lower than he does, then, instead of excluding the lowest, we may at once exclude all who stand lower than the said candidate.

When any candidates have been excluded, we need pay no attention to their names when we find them indicated on any voting papers, nor, when any candidates have been withdrawn, need we pay any attention to their names when distribution by selection takes place.

At the end of the election the total number of votes lost will give the number of electors who are not represented.

In order to test the method here described voting-papers were written out for a trial election. Care was taken to ensure that 3 candidates had each a considerable surplus, the largest being 4 quotas, and the smallest 1 quota, and that a considerable portion of this surplus should be transferable only to a few chosen candidates. No more than 3 contingent votes were allowed, and as to the rest, the papers were written pretty much at random. There were 19 vacancies and 26 candidates. The first quota was 100, and the last 63, and the candidate last returned was elected by 55 votes. The same election worked out by the method described in

the current number of the *Melbourne Review* returned 2 candidates not returned by the above process, and these were returned on 13 votes each.

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## Art. VII.—*On Some Curious Effects of Lightning at Gabo Island.*

By Arnold Lilly.

[Read August 10th, 1880.]

In the early part of January last I had occasion to visit the lighthouse and meteorological station upon Gabo Island. Two days before my arrival, on the 7th of the month, there had been a very severe thunderstorm, which traversed all the eastern districts of the colony and apparently came to a climax in the neighbourhood of Cape Howe and Gabo Island; here it raged for about three hours, accompanied by a full gale of wind and a very heavy sea. From what Mr. Fanning, the lighthouse-keeper, experienced in the lantern, and from what was seen by others outside, there is no doubt that the lighthouse was, in common parlance, struck by lightning. The lighthouse, I should explain, is built of granite, with a central iron column supporting the iron frame of the lantern which contains the light. There is a wire conductor connected with the lower part of the lantern, carried outside the lighthouse down to its base, and over the rocks into the sea, but there was apparently no pointed terminal upon the roof. In this case the lightning appears to have travelled down the iron column instead of down the wire conductor, and to have met with bad earth contact where it passed into the granite and concrete of the base, for Mr. Fanning states that the whole lighthouse seemed to rock from its foundations, and in the morning the pattern shown in the accompanying diagram was found traced in the sand, which was lying about a quarter of an inch thick on the basement floor of concrete; this sand was left undisturbed until my visit, and